BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

(Wholly owned Government of Karnataka Undertaking)

VOLUME-III

TECHNICAL SPECIFICATIONS

Enquiry No. BESCOM/2025-26/SE0400

"For Repairs and Reconditioning of 11KV class single coil/multi coil Conventional(Aluminium wound) and 3,4,5 Star Rated failed Distribution Transformers of various Capacities from 25 to 500 KVA and Conversion of CSP to Conventional bolt & nut type on lumpsum percentage(%) Rate basis (Material, Labour & Salvage) at Transformer repair center in Nonavinakere, Tiptur Division of BESCOM Jurisdiction"

ISSUED BY

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Operations-1, K.R Circle,

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SPECIFICATION FOR 11KV /O.433KV, CLASS ALUMINUM WOUND DISTRIBUTION TRANSFORMERS OF RATING 15KVA/25 KVA/63KVA/100KVA/200KVA/250KVA/300KVA/500KVA (Conventional Type)

1.0 STANDARDS:

The applicable standards for distribution transformers including various accessories are specified here below:

i.	Colours for Ready mixed paints &. Enamels	- IS: 5/1994
ii.	Ready mixed paint, brushing, Zinc Chrome, priming	- IS: 104/1979
iii.	New insulating oils	- IS: 335/1993
iv.	Methods for testing of Steel Sheets for Magnetic Circuits of Electrical apparatus	- IS: 649/1997
v.	Outdoor type three Phase distribution transformers Up to and including 100KVA, 11 KV class	- IS: 1180 /1989 (Part I &.II)
vi.	Solid press Boards for Electrical purposes	- IS: 1576/1992
vii.	Power Transformers	- IS: 2026/1977 (Parts 1 to 5)
viii.	Bushings for alternating voltages above 1000 volts	- IS: 2099/1986
ix.	Determination of water content by Karl Fischer method-Test method	- IS: 2362/1993
x.	Paper covered Aluminum conductors	- IS: 6162/1971 (Part I & II)
xi.	Rectangular conductors for Electrical Machines	- IS: 6160/1971
xii.	Dimensions for Porcelain Transformer	

	Bushing Dimensions for use in normal And lightly polluted atmosphere	- IS: 3347 (Part I - IV)
xiii.	Electric Power Connectors	- IS: 5561/1970
xiv.	Method of test for specific resistance (Resistivity) of Electrical insulating liquids	- IS: 6103/1971
xv.	Method of test for power factor and Dielectric Constant of electrical Insulating liquids	- IS: 6262/1971
xvi.	Method for Determination of electric strength of insulating oils	- IS:6792/1992
xvii.	Code of practice for selection Installation, Maintenance of Transformers	- IS: 10028/1985 (Part I to III)
xix.	CBIP Manual	- Section B & C
xx.	REC Specification	- No.2
xxi.	REC construction standards K.5 (Capitalization of losses)	- K5 (R-1993)

2.0 SYSTEM DETAILS:

The transformers shall be suitable for outdoor installation with 3Phase, 50 Hz, 11kV System in which the neutral is effectively earthed and the same shall be suitable for service under fluctuations in supply voltage up to 12% permissible under Indian Electricity Rules and the frequency variation of -5% and +2% (47.5Hz to 51.0Hz).

3.0 RATINGS:

Primary Voltage - 11 KV - 3Phase
Secondary Voltage - 433 Volts.

The winding of the transformers shall be connected in delta on the primary side and in star on the secondary side. The neutral of the LT windings shall be brought out to a separate terminal. The vector group shall be Dyn.l1.

4.0 TECHNICAL PARAMETERS:

a) **Percentage Impedance**:
The Percentage Impedance shall be 4.5% for transformers up to 200KVA and 5% for transformers of 250KVA upto 500KVA with tolerance as per IS: 2026.

b) **Temperature rise**:
The Temperature Rise for top oil over should be 45°C max (measured by thermometer as per IS: 2026) over the ambient temperature.

c) The temperature rise for windings shall not exceed 50°C Max. (Measured by resistance in accordance with IS: 2026) over the ambient

temperature.

d) **No Load Voltage Ratio**:
The No Load Voltage ratio shall be 11000/433-240V, for all capacities of distribution transformers at normal tap.

5.0 DESIGN & CONSTRUCTION:

Core:

a) The core shall be of high grade CRGO steel sheet *of* M4 grade or superior to that having low loss and non-ageing grain oriented, coated with hot oil proof insulation, bolted together to the frames firmly to prevent vibration or noise. All core clamping bolts shall be effectively insulated.

The complete design of core must ensure permanency of the core losses with continuous working of the transformers. The value of the flux density shall not be more than 1.7 tesla at 50 HZ.

The construction of core, internal clearances minimum effective area of cross section, minimum Nos. of core steps etc., shall be strictly as per the drawings enclosed.

b) The transformers core shall not be saturated for any value of V/F ratio to the extent of 112.5% of the rated value of V/F ratio i.e., 11kV/50Hz. (Due to combined effect of voltage and frequency) upto 12.5% without injurious heating at full load conditions the core shall not be saturated.

The Bidder shall furnish necessary design data in support of this condition

c) The maximum thickness of core laminations shall not exceed 0.3mm. Further the lamination sheets used for top yoke, bottom yoke etc., shall be of single piece.

d) No load current, shall be measured by energizing the transformers at 433 volts 50 C/S on the secondary for distribution transformers. Increase of voltage by 10% shall not increase the no load current disproportionately high. Test for magnetic balance by connecting the LV phase by phase to rated phase voltage and measurement of an, bn, cn, voltage shall be carried out. The no load current shall not exceed 2% in respect of 200KVA upto 750KVA Transformers and 4 to 5% in respect of 1000KVA and below distribution transformers at rated voltage and frequency.

The minimum
(1) Effective core area
(2) Number of core steps
(3) Internal clearance

Shall be as per the specification and drawings as indicated in the drawings for each capacity.

Minimum effective cross sectional area of the core to be provided are as follows:

1) 25KVA	-	41.18 sq.cm.
2) 63KVA	-	75.00 sq.cm.
3) 100KVA	-	84.60 sq.cm.
4) 250KVA	-	146.20 sq.cm.
5) 500KVA	-	218.00 sq.cm.

Note: If the manufacturer uses the better quality CRGO steel for the core the manufacturer has to furnish the area of cross section of the core along with the design details. For the other capacities of transformers cross sectional area may be designed to have minimum core losses as per relevant standards.

e) The unbalance current in the neutral shall not be more than 2% of the rated current.

6.0 CORE CLAMPING:

1) M.S. Channel 125 x 65mm for 500KVA, 100x50mm for 250 KVA 75 x 40mm for 100 KVA and below transformers on top and bottom shall be used for clamping the core for 300,750 & 1000KVA as per existing design.

2) High tensile vertical bolts in parallel in each side shall be provided. The size of the Bolts to be provided in parallel are as follows:

a) 25, 63, 100KVA - 4 Nos. of 12mm High Tensile Bolts
b) 200, 250, 300 KVA - 4 Nos. of 16mm High Tensile Bolts
c) 500 KVA - 4 Nos. of 20mm High Tensile Bolts

3) Channel on LV side to be reinforced at equidistance if hole cutting is done for LT lead so as to avoid bending of channel.

4) M.S. Channels are to be painted by varnish and corrosion oil resistant paint before use.

5) Flat or cut channel shall not be used.

6) Core mounting is to be done with ISF 50x10 for Transformers up to and including 100KVA & 50 X 16 for 250KVA and above rated transformer.

7) Clamping arrangement should be strong enough to withstand mechanical forces. The mechanical strength shall be proven by short circuit test.

7.0 TIE BOLTS:

Four horizontal tie rods (or high tensile steel) of 12mm dia for transformers up to l00KVA, 16mm for 200, 250, 300KVA, and 20mm for 500KVA & for 750 & 1000KVA as per existing design to be used. Rods to be effectively insulated with kraft paper tube of thickness I.5mm.

i) All top and bottom Yoke nuts bolts and tie rods shall be painted with oil and corrosion resistant paint before use.
ii) Channel - (top yoke) on LV side to be reinforced at equidistance if hole cutting is done to avoid bending of channel.
iii) The flat provided at the core shall be as per the drawings enclosed and shall not be cut through the length.
iv) Tie rods shall be effectively earthed.
v) Drawing of the building of the core shall be got approved before start of the work

8.0 WINDINGS:

a) **Material-** Double layer paper covered Aluminum conductor shall be used.
b) The nominal HV winding cross section shall be as follows:

SL. No.	Rating	Cross section
1	15KVA	As per relevant IS standards/ existing design
2	25KVA	0.7854 Sq.mm.
3	63KVA	1.539 Sq.mm.
4	100KVA	2.270 Sq.mm.
5	200KVA	As per relevant IS standards/ existing design
6	250KVA	7.069 Sq.mm.
7	300KVA	As per relevant IS standards/ existing design
8	500KVA	12.050 Sq.mm.

c) The nominal LV winding cross section shall be as follows:

SL. No.	Rating	Cross section
1	15KVA	As per relevant IS standards/ existing design
2	25KVA	18.33 Sq.mm.
3	63KVA	49.39 Sq.mm.
4	100KVA	83.08 Sq.mm.
5	200KVA	As per relevant IS standards/ existing design
6	250KVA	286.44 Sq.mm.
7	300KVA	As per relevant IS standards/ existing design
8	500KVA	417.06 Sq.mm.

d) LV winding shall be in even layers
e) The neutral formation shall be at top

9.0 LOSSES & IMPEDANCE:

The losses and impedance for various ratings of transformers of 11KV/433V class shall be within the permissible limits. These losses are the maximum permissible.

Rating (KVA)	No load loss watts (Max.)	Tolerance	Full load loss (watts) (Max.)	Tolerance	Total tolerance for full load and	Impedance % (subject to tolerance as per IS:2026)

					no load losses	
25	100	5%	685	5%	5%	4.5
63	180	5%	1235	5%	10%	4.5
100	260	5%	1760	5%	10%	4.5
200	400	20%	3000	20%	15%	5.0
250	500	20%	3000	20%	15%	5.0
300	580	20%	3630	20%	15%	5.0
500	850	20%	5800	20%	15%	5.0

10.0 INSULATION, INSULATION MATERIAL & CLEARANCES:

10.1 Press board blocks at top and bottom of each coil assembly shall be provided. There must be atleast 4 blocks per phase/coil of each of thickness of 30mm. Core wrapper shall be of minimum of 1mm thick.

The channel at phase barrier board shall be of 2mm thick press board. The tie rod insulation kraft paper shall be of thickness 1mm. Between HV and LV windings addition press Board cylinder of at least 2mm in addition to spacers shall also be provided.

10.2 No. of vertical/axial wedges up to 100 KVA minimum 18 Nos. and for 250 KVA &. 500KVA - 12 Nos. shall be provided depending upon the capacity of transformers between LV and HV windings and equi spaced around LV. The wedge shall be minimum 6.5mm thick and 8-12mm wide.

10.3 The inter layer insulation shall be provided between HV windings layers depending on the design. The details shall be furnished.

10.4 The Neutral connection of LT winding shall be formed using aluminum strip of same size as that of 'S' type link of size 25x3mm. Aluminum strip for 25/63/l00 KVA and 40x5mm for 250KVA and 70x5 mm for 500KVA transformers.

10.5 The Delta formation of HV winding shall be made using copper jumper leads of size 1.6mm dia. for 25/63/100KVA, 2.65MM for 250KVA and 3.75 MM for 500KVA transformers. The leads shall be enclosed in Kraft insulated paper tube.

10.6 Double paper covering shall be used for winding insulation both for HV & LV windings. Either performed corrugated cylindrical boards or cylindrical compressed boards with spacers shall be provided between HV & LV windings. Press board of type - D IS: 1576 to be used for top and bottom yoke insulation. The electrical grade insulating paper shall be of triveni/Ballarpur or equivalent make subject to approval of BESCOM. Press boards used shall be of M/s. Senapathi whitely or M/s. Raman Boards or equivalent make subject to approval of BESCOM.

10.7 Radial clearance of LV coil to core (bare conductor) shall not be less than.

1. 25 KVA - 3.5MM
2. 63 KVA - 3.5MM
3. 100KVA - 4.0MM
4. 200KVA - As per relevant IS standards/ existing design

5. 250KVA - 5.0MM
6. 300KVA - As per relevant IS standards/ existing design
7. 500KVA - 5.0MM

10.8 Radial clearance between HV and LV coils shall not be less than 10mm for all capacities.

10.9 Phase to phase clearance between HV coils shall not be less than 15mm. A minimum of 2 Nos. of 1mm press board shall be used to cover the tie rods.

10.10 The minimum electrical clearance between the winding and body of the tank (between inside surface of the tank and outside edge of the winding) shall not be less than 30mm.

10.11 End insulation to earth shall not be less than 25mm.

10.12 HV & LV coils single coil multilayer winding shall be used for all capacities of transformers.

10.13 Tap lead shall be insulated with 1.5 mm thick paper insulation. Inspection of windings prior to tankings shall be done. Manufacturing drawing for the transformer showing various clearance shall have to be approved by the BESCOM.

11.0 TOTAL MINIMUM OIL VOLUME:

Sl. No.	Rating	Oil in Ltrs. (inclusive for oil absorbed in core coil assembly)
1	15KVA	80
2	25KVA	85
3	63KVA	115
4	100KVA	140
5	200KVA	340
6	250KVA	340
7	300KVA	400
8	400KVA	400
9	500KVA	420

12.0 FILLING OF SILICAGEL IN BREATHERS :

The volume of the breather shall be

a) 250 grams of silica gel breather shall be provided for 25 KVA, 63 KVA and 100 KVA transformers.
b) For 200KVA, 250 KVA, 300KVA, and 500KVA transformers 500Gms. breather shall be provided.

13.0 TERMINALS:

a) Brass rods 12mm dia for HT, 20mm dia for LT for 200 KVA and 250KVA and 12mm dia for HT and 30mm dia for 500KVA & above transformers shall be provided.

b) HT/LT Bimetallic connectors shall be provided to 15 KVA to 1000KVA transformers.

c) Connecting lugs shall be provided confirming to IS: 3347 for LT terminals of 200KVA and above Transformers.

d) The metallic connector shall be L type for LT bushing of distribution transformer of capacity of 100, 250 and 500KVA.

e) The L type clamp shall be suitable to take off two/four circuits of 240 Sq. mm aluminum wire (for 250KVA & above transformers)

f) The HV and LV windings conductor shall not be terminated to the bushing rod directly.

g) The HV winding shall be linked through a terminal lug and copper jumper lead of size 1.6mm dia for 25/63/100KVA, 2.65mm for 250KVA and 3.75mm for 500KVA transformers. The leads shall be enclosed in kraft paper tube.

h) The LV winding shall be terminated using inverted 'S' type link of size 25x3mm Aluminum strip for 25/63/100KVA, 40x5mm for 250KVA and 70x5mm for 500KVA transformers.

1) All the leads / links shall be immersed in oil.

2) All the leads/links shall be taken neatly strapped on an insulated press Board/wooden Bus Bar.

14.0 BUSHINGS:

I. For 11KV, 12KV Bushings (confirming to IS: 2099/1986) with single gap arcing horns shall be used and for 433 volts, 1.1KV terminal Bushings confirming to IS: 7421/1974shall be used. Bushings of the same voltage class shall be inter changeable. The dimensions of Bushings shall be as per IS-3347 and these Bushings shall be mounted on side of the tank or on the top cover. The bushings mounted on the side shall not have an inclination of more than 30 degrees from the vertical as per CBIP manual and IS-2099. Only sheet metal pocket shall be provided for mounting HV bushings alternately the same can be mounted on pipes. Creepage distance shall not be less than 25mm/KV as per IS: 2099-1986.

II. **Brazing of all internal connections** – All jumpers from windings to bushing shall have a cross section larger than tile winding conductor. For copper, silver brazing alloy to be used. For aluminium, L&T aluminum brazing rods shall be used.

III. The minimum phase to phase and phase to earth external clearances for HV & LV Bushings shall be as follows:

	Minimum clearances	
	Phase to phase (in mm).	Phase to earth
HV Bushings	255	140
LV Bushings	75	40

The above 140 mm. clearance does not apply to arcing horn gap.

15.0 TESTS:

Type tests, routine tests and acceptance tests shall be conducted on transformers, of each capacity. All the equipments offered, shall be fully type tested as per the relevant standards.

15.1 Routine Tests:

All transformers manufactured shall be subjected to the following routine test, at the manufacturer's works - In accordance with IS:1180 (Part I & II) and IS:2026.

1) Measurement of winding resistance.
2) Measurement of voltage ratio and Check of voltage vector relationship
3) Measurement of impedance voltage/short circuit impedance and load loss.
4) Measurement of no load loss current and neutral current.
5) Measurement insulation resistance.
6) Induced over voltage withstand test.
7) Separate source voltage withstand test.

16.0 TOLERANCES:

Unless otherwise specified herein, the values of different parameters of the transformers supplied shall be within the tolerance permitted in the IS-2026 on the guaranteed values. Positive tolerance is not applicable for losses and negative tolerance not applicable for cross sections of winding specified.

17.0 FINISHING:

The exterior of the transformer tank and other ferrous fittings shall be thoroughly cleaned, scrapped/sand blasted and given a priming coat and two finishing coats of durable oil the weather resistance paints or enamel. The colour of finishing coats for transformers shall be as follows, as per IS: 5.

a) For 15/25 KVA - Sky Blue shade No. 101
b) For 63 KVA - Silver Grey shade No. 628
c) For 100 KVA - Brilliant green shade No. 221
d) For 200/250/300 KVA } Dark admiral grey shade No. 632
e) For 400/500 KVA }

18.0 TESTING FACILITY:

The supplier shall have adequate testing facility to conduct the routine tests.

19.0 Adoptability of Multi coil winding in repairing of failed DTR's failed:

19.01 The bidder has to repair the failed Transformers using Multi Coil System of adoptability where ever possible with the existing design of Transformers if all the coils are to be replaced.

19.02 The bidder shall repair with single winding if it is not feasible to

adopt multi coil system.

19.03 The AEE/EE(MT) has to specify in Joint inspection report-3 whether to repair the transformers with single/multi coil.

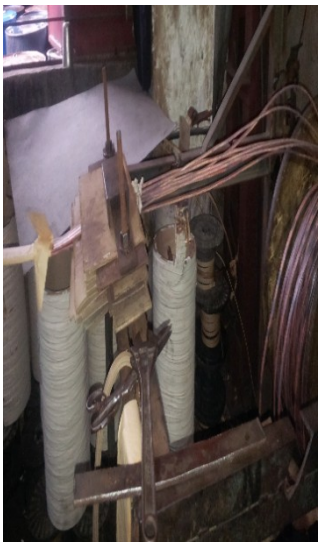
20.0 Photos of Multi Coil winding transformers:

Single segment of Multi winding

Staggered segments of Multi winding

Assemble segments of Multi winding

Re-insulation of Secondary winding (LT)



Damaged segment of HT

Technical Specification for 3 Star Rated, 11/0.433kV, 3Phase, 50Cycle, Aluminium Wound Distribution Transformer of rating 15/16, 25/63/100/250/500 kVA

1.0 SYSTEM DETAILS:

The transformers shall be suitable for outdoor installation with 3Phase, 50 Hz, 11kV System in which the neutral is effectively earthed and the same shall be suitable for service under fluctuations in supply voltage up to 12% permissible under Indian Electricity Rules and the frequency variation of -5% and +2% (47.5Hz to 51.0Hz).

2.0 TECHNICAL REQUIREMENTS:

Core Material: CRGO Material

The core shall be high grade stack/wound type of high grade cold rolled grain oriented annealed steel lamination having low loss and good grain properties, coated with hot oil proof insulation, bolted together and to the framed to prevent vibration or noise. The core shall be stress relived by annealing under inert atmosphere if required. The complete design of core must ensure permanency of the core loss with continuous working of the transformers. The value of the maximum flux density allowed in the design and grade of lamination used shall be clearly stated in the offer.

The bidder should offer the core for inspection and approval by the purchaser during manufacturing stage.

The transformers core shall be suitable for over fluxing (due to combined affect of voltage and frequency) up to 12.5% without injurious heating at full load conditions and shall not get saturated. The bidder shall furnish necessary design data in support of this situation.

No-load current shall not exceed 3% of full load current and will be measured by energising the transformer at 433 volts, 50Hz on the secondary. Increase of voltage of 433 volts by 12.5% shall not increase the no-load current by 6% (maximum) full load current.

3.0 WINDINGS:

HV and LV windings shall be wound from Super Enamel covered/ Double Paper covered aluminium conductor.

LV windings shall be such that neutral formation will be at top.

Inter layer insulation shall be Nomex/Epoxy dotted Kraft Paper.

Proper bonding of inter layer insulation with the conductor shall be ensured. Test for bonding strength shall be conducted.

Dimensions of winding coils are very critical. Dimensional tolerances for windings coils shall be within limits as specified in Guaranteed Technical Particulars.

Current density for HV and LV winding should not be more than 1.6 Ampere per sq mm for aluminium conductor.

The core/coil assembly shall be securely held in position to avoid any movement under short circuit conditions.

Joints in the winding shall be avoided. However, if jointing is necessary the joints shall be properly brazed and the resistance of the joints shall be less than that of parent conductor.

4.0 PERCENTAGE IMPENDENCE:

The value of impedance of transformer at 75°C shall be 4.5% shall be in accordance with IS: 2026.

5.0 NO LOAD VOLTAGE RATIO:

The No Load Voltage ratio shall be 11000/433-240V, for all capacities of distribution transformers at normal tap.

6.0 INSULATION LEVELS:

Sl No.	Voltage (kV)	Impulse Voltage (kV Peak)	Power Frequency Voltage (kV)
1	0.433	-	3
2.	11	95	28

7.0 DESIGN & CONSTRUCTION:

CORE:

a) The core shall be of high grade CRGO steel sheet of 23ZDMH85 or superior to that having low loss and non ageing grain oriented, coated with hot oil proof insulation, bolted together to the frames firmly to prevent vibration or noise. All core clamping bolts shall be effectively insulated.

The complete design of core must ensure permanency of the core losses with continuous working of the transformers. The value of the flux density shall not be more than 1.7 tesla at 50 HZ.

The construction of core, internal clearances minimum effective area of cross section, minimum Nos. of core steps etc., shall be strictly as per the drawings enclosed.

b) The transformers core shall not be saturated for any value of V/F ratio to the extent of 112.5% of the rated value of V/F ratio i.e., 11kV/50Hz. (Due to combined effect of voltage and frequency) upto 12.5% without injurious heating at full load conditions the core shall not be saturated.

The Bidder shall furnish necessary design data in support of this condition

c) The maximum thickness of core laminations shall not exceed 0.3mm.

Further the lamination sheets used for top yoke, bottom yoke etc., shall be of single piece.

d) No load current, shall be measured by energizing the transformers at 433 volts 50 C/S on the secondary for distribution transformers. Increase of voltage by 10% shall not increase the no load current disproportionately high. Test for magnetic balance by connecting the LV phase by phase to rated phase voltage and measurement of an, bn, cn, voltage shall be carried out. The no load current, shall not exceed 3% in respect of 100KVA and below distribution transformers, at rated voltage and frequency.

The minimum
1.Effective core area
2.Number of core steps
3.Internal clearance
Shall be furnished by the bidder along with the bid offer.
Minimum effective cross sectional area of the core to be provided are as follows:

1) 25KVA	-	41.18 sq.cm.
2) 63KVA	-	75.00 sq.cm.
3) 100KVA	-	84.60 sq.cm.
4) 250KVA	-	146.20 sq.cm.
5) 500KVA	-	218.00 sq.cm

e) The unbalance current in the neutral shall not be more than 2% of the rated current.

8.0 CORE CLAMPING:

1) M.S.Channel 75 x 40mm for 100 KVA and below transformers on top and bottom shall be used for clamping the core.

2) 2 Nos. of 12mm high tensile vertical bolts in parallel in each side shall be provided. The size of the Bolts to be provided in parallel are as follows:

a) 25, 63, 100KVA	- 4 Nos. of 12mm High Tensile Bolts
b) 200, 250, 300 KVA	- 4 Nos. of 16mm High Tensile Bolts
c) 500 KVA	- 4 Nos. of 20mm High Tensile Bolts

Channel on LV side to be reinforced at equidistance if hole cutting is done for LT lead so as to avoid bending of channel.

4) M.S. Channels are to be painted by varnish and corrosion oil resistant paint before use.

5) Flat or cut channel shall not be used.

6) Core mounting is to be done with ISF 50x10 for Transformers up to and including 100KVA transformer.

7) Clamping arrangement should be strong enough to withstand mechanical forces. The mechanical strength shall be proven by short circuit test.

9.0 TIE BOLTS:

Four horizontal tie rods (or high tensile steel) of 12mm dia for transformers up to l00KVA to be used. Rods to be effectively insulated with kraft paper

tube of thickness I.5mm.

1. All top and bottom Yoke nuts bolts and tie rods shall be painted with oil and corrosion resistant paint before use.
2. Channel - (top yoke) on LV side to be reinforced at equidistance if hole cutting is done to avoid bending of channel.
3. The flat provided at the core shall be as per the drawings enclosed and shall not be cut through the length.
4. Tie rods shall be effectively earthed.
5. Drawing of the building of the core shall be got approved before start of the work

7.0 Material: Double layer paper covered Aluminium conductor shall be used. The nominal HV winding cross section shall be as follows:

SL. No.	Rating	Cross section
1	15/16 KVA	As per relevant standards/existing design
2	25KVA	0.7854 Sq.mm.
3	63KVA	1.539 Sq.mm.
4	100KVA	2.270 q.mm.
5	250KVA	7.069 Sq.mm
6	500KVA	12.04 Sq.mm

The nominal LV winding cross section shall be as follows:

SL. No.	Rating	Cross section
1	15/16 KVA	As per relevant standards/existing design
2	25KVA	18.33 Sq.mm.
3	63KVA	49.39 Sq.mm.
4	100KVA	83.08 Sq.mm.
5	250KVA	286.44 Sq.mm
6	500KVA	417.06 Sq.mm

8) LV winding shall be in even layers

9) The neutral formation shall be at top

Note: If any other than the above cross section of HV/LV windings, details shall be furnished.

11.0. LOSSES AND IMPEDANCE:

The Bidder shall guarantee individually the no-load losses and loss without any positive tolerance. The Bidder shall also guarantee the total losses at 50% and 100% load condition (at rated voltage and frequency and at 75°C).

The maximum allowable losses & impedance at rated voltage and rated frequency permitted at 75°C for 11/0.433kV transformers as follows:

Voltage ratio:	Ratings (kVA)	Max Losses at 50% loading (watts)	Max Losses at 100% loading (watts)	Impedance % (subject to tolerance as per IS:2026)
11kV/433-250V	25	210	695	4.5
	63	380	1250	

	100	520	1800	

12.0 TOLERANCE:

No positive tolerance shall be allowed on the maximum losses displayed on the label for both 50% and 100% loading values.

13.0 INSULATION, INSULATION MATERIAL& CLEARANCES:

Electrical grade insulation epoxy dotted Kraft Paper/Nomex and pressboard of standard make or any make other superior material subject to approval of the BESCOM shall be used.

All spacers, axial wedges/runners used in windings shall be made of pre-compressed Pressboard-solid, conforming to type B 3.1 of IEC641-3-2. In case of cross- over coil winding of HV all spacers shall be properly sheared and dovetail punched to ensure proper locking. All axial wedges/runners shall be properly milled to dovetail shape so that they pass through the designed spacers freely. Insulation shearing, cutting, milling and punching operations shall be carried out in such a way, that there should not be any burr and dimensional variations.

a) Press board blocks at top and bottom of each coil assembly shall be provided. There must be atleast 4 blocks per phase/coil of each of thickness of 30mm. Core wrapper shall be of minimum of 1mm thick.

   The channel at phase barrier board shall be of 2mm thick press board. The tie rod insulation craft paper shall be of thickness 1mm. Between HV and LV windings addition press Board cylinder of at least 2mm in addition to spacers shall also be provided.

b) No. of vertical/axial wedges up to 100 KVA minimum 18 Nos., shall be provided depending upon the capacity of transformers between LV and HV windings and equispaced around LV. The wedge shall be minimum 6.5mm thick wide.

c) The inter layer insulation shall be provided between HV windings layers depending on the design. The details shall be furnished.

d) The Neutral connection of LT winding shall be formed using aluminium strip of same size as that of 'S' type link of size 25x3mm. Aluminium strip for 25/63/l00 KVA transformers.

e) The Delta formation of HV winding shall be made using copper jumper leads of size 1.6mm dia. for 25/63/100KVA, 2.65MM transformers. The leads shall be enclosed in Kraft insulated paper tube.

f) Double paper covering shall be used for winding insulation both for HV & LV windings. Either performed corrugated cylindrical boards or cylindrical compressed boards with spacers shall be provided between HV & LV windings. Press board of type - D IS: 1576 to be used for top and bottom yoke insulation. The electrical grade insulating paper shall be of Triveni/Ballarpur or equivalent make subject to approval of BESCOM. Press boards used shall be of M/s. Senapathi whitely or M/s. Raman Boards or equivalent make subject to approval of BESCOM.

g) Radial clearance of LV coil to core (bare conductor) shall not be less than.

1. for 15/16 KVA - As per IS standards/ existing design
2. for 25 KVA - 3.5MM
3. for 63 KVA - 3.5MM
4. for 100KVA - 4.0MM
5. for 250KVA - 5.0MM
6. for 500KVA - 5.0MM

h) Radial clearance between HV and LV coils shall not be less than 10mm for all capacities.

i) Phase to phase clearance between HV coils shall not be less than 15mm. A minimum of 2 Nos. of 1mm press board shall be used to cover the tie rods.

j) The minimum electrical clearance between the winding and body of the tank (between inside surface of the tank and outside edge of the winding) shall not be less than 30mm.

k) End insulation to earth shall not be less than 25mm.

l) HV & LV coils single coil multi layer winding shall be used for all capacities of transformers.

m) Tap lead shall be insulated with 1.5 mm thick paper insulation. Inspection of windings prior to tanking shall be done. Manufacturing drawing for the transformer showing various clearance shall have to be approved by the BESCOM.

14.0 TOTAL MINIMUM OIL VOLUME:

Sl. No.	Rating	Oil in Ltrs. (inclusive for oil absorbed in core coil assembly)
1	15/16KVA	80
2	25KVA	85
3	63KVA	115
4	100KVA	140
4	250KVA	340
5	500KVA	420

15.0 FILLING OF SILICAGEL IN BREATHERS :

The volume of the breather shall be

a) 250 grams of silica gel breather shall be provided for 15/16 KVA, 25 KVA, 63 KVA and 100 KVA transformers.

16.0 TERMINALS:

Brass rods 12mm dia for HT and LT for 15/16 KVA, 25KVA, 63KVA and 100KVA Transformers may be provided.

a) HT/LT Bimetallic connectors shall be provided to 15/16 KVA, 25KVA, 63KVA and 100KVA transformers.

b) The metallic connector shall be L type for LT bushing of distribution transformer of capacity of 100.

c) The HV and LV windings conductor shall not be terminated to the bushing rod directly.

d) The HV winding shall be linked through a terminal lug and copper jumper lead of size 1.6mm dia for 15/16, 25/63/100KVA transformers. The leads shall be enclosed in kraft paper tube.

e) The LV winding shall be terminated using inverted 'S' type link of size 25x3mm Aluminium strip for 15/16, 25/63/100KVA transformers.

1) All the leads / links shall be immersed in oil.
2) All the leads/links shall be taken neatly strapped on an insulated press Board/wooden Bus Bar.

17.0 BUSHINGS:

I. For 11KV, 12KV Bushings (confirming to IS: 2099/1986) with single gap arcing horns shall be used and for 433 volts, 1.1KV terminal Bushings confirming to IS: 7421/1974shall be used. Bushings of the same voltage class shall be interchangeable. The dimensions of Bushings shall be as per IS-3347 and these Bushings shall be mounted on side of the tank or on the top cover. The bushings mounted on the side shall not have an inclination of more than 30 degrees from the vertical as per CBIP manual and IS-2099. Only sheet metal pocket shall be provided for mounting HV bushings alternately the same can be mounted on pipes. Creepage distance shall not be less than 25mm/KV as per IS: 2099-1986.

II. **Brazing of all internal connections** – All jumpers from windings to bushing shall have a cross section larger than tile winding conductor. For copper, silver brazing alloy to be used. For aluminium, L&T aluminium brazing rods shall be used.

III. The minimum phase to phase and phase to earth external clearances for HV & LV Bushings shall be as follows:

	Minimum clearances	
	Phase to phase (in mm).	**Phase to earth**
HV Bushings	255	140
LV Bushings	75	40

The above 140 mm. clearance does not apply to arcing horn gap.

18.0 TESTS:

Type tests, routine tests and acceptance tests shall be conducted on transformers, of each capacity. All the equipments offered, shall be fully type tested as per the relevant standards.

19.0Routine Tests:

All transformers manufactured shall be subjected to the following routine test, at the manufacturer's works - In accordance with IS:1180 (Part I & II) and IS:2026.

1) Measurement of winding resistance.
2) Measurement of voltage ratio, polarity, phase sequence and Check of

voltage vector relationship

3) Measurement of impedance voltage/short circuit impedance and load losses at rated current and normal frequency.
4) Measurement of no load loss current and neutral current.
5) Measurement insulation resistance.
6) Induced over voltage withstand test.
7) Separate source voltage withstand test.
8) Neutral current measurement: The value of zero sequence current in the neutral of the star winding shall not be more than 2% of the full load current.
9) Oil samples (one sample per lot) to comply with IS: 1866.
10) Measurement of no load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.
11) Pressure and vacuum test for checking the deflection.

20.0 TOLERANCES:

Unless otherwise specified herein, the values of different parameters of the transformers supplied shall be within the tolerance permitted in the IS-2026 on the guaranteed values. Positive tolerance is not applicable for losses and negative tolerance not applicable for cross sections of winding specified.

21.0 FINISHING:

The exterior of the transformer tank and other ferrous fittings shall be thoroughly cleaned, scrapped/sand blasted and given a priming coat and two finishing coats of durable oil the weather resistance paints or enamel. The colour of finishing coats for transformers shall be as follows, as per IS: 5.

a) For 15/16KVA - Sky Blue shade No. 101
b) For 25 KVA - Sky Blue shade No. 101
c) For 63 KVA - Silver Grey shade No. 628
d) For 100 KVA - Brilliant green shade No. 221

BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

Technical Specification for 4Star Rated (New Star1)11/0.433kV, 3Phase, 50Cycle, Aluminium Wound CRGO Core Distribution Transformer of rating 25/63/100kVA

1.0 SYSTEM DETAILS:

The transformers shall be suitable for outdoor installation with 3Phase, 50 Hz, 11kV System in which the neutral is effectively earthed and the same shall be suitable for service under fluctuations in supply voltage up to 12.5% permissible under Indian Electricity Rules and the frequency variation of -5% and +2% (47.5Hz to 51.0Hz).

2.0 TECHNICAL REQUIREMENTS:

Core Material: CRGO Material

a) The core shall be high grade stack/wound type of high grade cold rolled grain oriented annealed steel lamination having low loss and good grain proper ties, coated with hot oil proof insulation, bolted together and to the framed to prevent vibration or noise. The core shall be stress relived by annealing under inert atmosphere if required. The complete design of core must ensure permanency of the core loss with continuous working of the transformers. The value of the maximum flux density allowed in the design and grade of lamination used shall be clearly stated in the offer.

b) The bidder should offer the core for inspection and approval by the purchaser during manufacturing stage.

c) The transformers core shall be suitable for over fluxing (due to combined effect of voltage and frequency) up to 12.5% without injurious heating at full load conditions and shall not get saturated. The bidder shall furnish necessary design data in support of this situation.

d) No-load current shall not exceed 3% of full load current and will be measured by energising the transformer at 433 volts, 50Hz on the secondary. Increase of voltage of 433 volts by 12.5% shall not increase the no-load current by 6% (maximum) full load current.

3.0 WINDINGS:

a) The primary winding shall be connected in delta and the secondary winding in star (vector symbol Dyn11) so as to produce, a positive phase displacement of 30 degrees from the primary to the secondary vectors of the same phase. The neutral of the secondary winding shall be brought out to a separate insulated terminal.

b) HV and LV windings shall be wound from Super Enamel covered/ Double Paper covered aluminium conductor.

c) LV windings shall be such that neutral formation will be at top.

d) Inter layer insulation shall be Nomex/Epoxy dotted Kraft Paper.

e) Proper bonding of inter layer insulation with the conductor shall be ensured. Test for bonding strength shall be conducted.

f) Dimensions of winding coils are very critical. Dimensional tolerances for windings coils shall be with in limits as specified in Guaranteed Technical Particulars.

g) Current density for HV and LV winding should not be more than 1.6 Ampere per sq mm for aluminium conductor.

h) The core/coil assembly shall be securely held in position to avoid any movement under short circuit conditions.

i) Joints in the winding shall be avoided. However, if jointing is necessary the joints shall be properly brazed and the resistance of the joints shall be less than that of parent conductor.

4.0 PERCENTAGE IMPENDENCE:

The value of impedance of transformer at 75°C shall be 4.5% and tolerance shall be in accordance with IS: 1180(part I) 2014.

5.0 NO LOAD VOLTAGE RATIO:

The No Load Voltage ratio shall be 11000/433-240V, for all capacities of distribution transformers at normal tap.

6.0 INSULATION LEVELS:

Sl No.	Voltage (kV)	Impulse Voltage (kV Peak)	Power Frequency Voltage (kV)
1	0.433	-	3
2.	11	75	28

7.0 DESIGN & CONSTRUCTION:

CORE:

a) The core shall be of high grade CRGO steel sheet of M3 or superior to that having low loss and non-ageing grain oriented, coated with hot oil proof insulation, bolted together to the frames firmly to prevent vibration or noise. All core clamping bolts shall be effectively insulated.

b) The complete design of core must ensure permanency of the core losses with continuous working of the transformers. The value of the flux density shall not be more than 1.7 tesla at 50 HZ.

c) The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with +12.5% combined voltage and frequency variation from rated voltage and frequency shall not exceed 1.9 Tesla

d) The construction of core, internal clearances minimum effective area of cross section, minimum Nos. of core steps etc., shall be strictly as per the drawings enclosed.

e) The transformers core shall not be saturated for any value of V/F ratio to

the extent of 112.5% of the rated value of V/F ratio i.e., 11kV/50Hz. (Due to combined effect of voltage and frequency) upto 12.5% without injurious heating at full load conditions the core shall not be saturated.

f) The Bidder shall furnish necessary design data in support of this condition

g) The maximum thickness of core laminations shall not exceed 0.23mm. Further the lamination sheets used for top yoke, bottom yoke etc., shall be of single piece.

h) No load current, shall be measured by energizing the transformers at 433 volts 50 C/S on the secondary for distribution transformers. Increase of voltage by 10% shall not increase the no load current disproportionately high. Test for magnetic balance by connecting the LV phase by phase to rated phase voltage and measurement of an, bn, cn, voltage shall be carried out. The no load current, shall not exceed 3% in respect of 100KVA and below distribution transformers, at rated voltage and frequency.

i) The minimum

(1) Effective core area
(2) Number of core steps
(3) Internal clearance

Shall be furnished by the bidder along with the bid offer.

Minimum effective cross sectional area of the core to be provided are as follows:

1) 25KVA - 41.18 sq.cm.
2) 63KVA - 84.60 sq.cm.
3) 100KVA - 105.65sq.cm.

Note: If the manufacturer uses the better quality CRGO steel for the core the manufacturer has to furnish the area of cross section of the core along with the design details.

j) The unbalance current in the neutral shall not be more than 2% of the rated current.

8.0 CORE CLAMPING:

1) M.S.Channel 75 x 40mm for 100 KVA and below transformers on top and bottom shall be used for clamping the core.

2) 2 Nos. of 12mm high tensile vertical bolts in parallel in each side shall be provided. The size of the Bolts to be provided in parallel are as follows:
   a) 25, 63, 100KVA - 2 Nos. of 12mm High Tensile Bolts

3) Channel on LV side to be reinforced at equidistance if hole cutting is done for LT lead so as to avoid bending of channel.

4) M.S. Channels are to be painted by varnish and corrosion oil resistant paint before use.

5) Flat or cut channel shall not be used.

6) Core mounting is to be done with ISF 50x10 for Transformers up to and including 100KVA transformer.

7) Clamping arrangement should be strong enough to withstand mechanical forces. The mechanical strength shall be proven by short circuit test.

9.0 TIE BOLTS:

Four horizontal tie rods (or high tensile steel) of 12mm dia for transformers up to l00KVA to be used. Rods to be effectively insulated with kraft paper tube of thickness I.5mm.

i) All top and bottom Yoke nuts bolts and tie rods shall be painted with oil and corrosion resistant paint before use.
ii) Channel - (top yoke) on LV side to be reinforced at equidistance if hole cutting is done to avoid bending of channel.
iii) The flat provided at the core shall be as per the drawings enclosed and shall not be cut through the length.
iv) Tie rods shall be effectively earthed.
v) Drawing of the building of the core shall be got approved before start of the work

10.0 WINDINGS:

a) **Material-** Double layer paper covered Aluminium conductor shall be used.

b) The nominal HV winding cross section shall be as follows:

SL. No.	**Rating**	
1	25KVA	0.9503 Sq.mm.
2	63KVA	2.835 Sq.mm.
3	100KVA	4.5239 Sq.mm.

c) The nominal LV winding cross section shall be as follows:

SL. No.	**Rating**	
1	25KVA	40.3 Sq.mm.
2	63KVA	90.44 Sq.mm.
3	100KVA	159.32 Sq.mm.

d) LV winding shall be in even layers

e) The neutral formation shall be at top

Note: If any other than the above cross section of HV/LV windings, details shall be furnished.

11.0LOSSES AND IMPEDANCE:

The bidder shall guarantee individually the no-load losses and loss without any positive tolerance. The bidder shall also guarantee the total losses at 50% and 100% load condition (at rated voltage and frequency and at 75°C).

The maximum allowable losses & impedance at rated voltage and rated frequency permitted at 75°C for 11/0.433kV transformers as follows:

Voltage ratio:	Ratings (kVA)	Max Losses at 50% loading (watts)	Max Losses at 100% loading (watts)	Impedance % (subject to tolerance as per IS:2026)
11kV/433-250V	25	190	635	4.5
	63	340	1140	
	100	475	1650	

12.0TOLERANCE:

No positive tolerance shall be allowed on the maximum losses displayed on the label for both 50% and 100% loading values.

13.0INSULATION, INSULATION MATERIAL& CLERANCES:

Electrical grade insulation epoxy dotted Kraft Paper/Nomex and pressboard of standard make or any make other superior material subject to approval of the BESCOM shall be used.

All spacers, axial wedges/runners used in windings shall be made of pre-compressed Pressboard-solid, conforming to type B 3.1 of IEC641-3-2. In case of cross- over coil winding of HV all spacers shall be properly sheared and dovetail punched to ensure proper locking. All axial wedges/runners shall be properly milled to dovetail shape so that they pass through the designed spacers freely. Insulation shearing, cutting, milling and punching operations shall be carried out in such a way, that there should not be any burr and dimensional variations.

a) Press board blocks at top and bottom of each coil assembly shall be provided. There must be atleast 4 blocks per phase/coil of each of thickness of 30mm. Core wrapper shall be of minimum of 1mm thick.

   The channel at phase barrier board shall be of 2mm thick press board. The tie rod insulation craft paper shall be of thickness 1mm. Between HV and LV windings addition press Board cylinder of at least 2mm in addition to spacers shall also be provided.

b) No. of vertical/axial wedges up to 100 KVA minimum 18 Nos., shall be provided depending upon the capacity of transformers between LV and HV windings and equispaced around LV. The wedge shall be minimum 6.5mm thick wide.

c) The inter layer insulation shall be provided between HV windings layers depending on the design. The details shall be furnished.

d) The Neutral connection of LT winding shall be formed using aluminium strip of same size as that of 'S' type link of size 25x3mm. Aluminium strip for 25/63/l00 KVA transformers.

e) The Delta formation of HV winding shall be made using copper jumper leads of size 1.6mm dia. for 25/63/100KVA, 2.65MM transformers. The

leads shall be enclosed in Kraft insulated paper tube.

f) Double paper covering shall be used for winding insulation both for HV & LV windings. Either performed corrugated cylindrical boards or cylindrical compressed boards with spacers shall be provided between HV & LV windings. Press board of type - D IS: 1576 to be used for top and bottom yoke insulation. The electrical grade insulating paper shall be of Triveni/Ballarpur or equivalent make subject to approval of BESCOM. Press boards used shall be of M/s. Senapathi whitely or M/s. Raman Boards or equivalent make subject to approval of BESCOM.

g) Radial clearance of LV coil to core (bare conductor) shall not be less than.
1. for 25 KVA - 3.5MM
2. for 63 KVA - 3.5MM
3. for 100KVA - 4.0MM

h) Radial clearance between HV and LV coils shall not be less than 10mm for all capacities.

i) Phase to phase clearance between HV coils shall not be less than 15mm. A minimum of 2 Nos. of 1mm press board shall be used to cover the tie rods.

j) The minimum electrical clearance between the winding and body of the tank (between inside surface of the tank and outside edge of the winding) shall not be less than 30mm.

k) End insulation to earth shall not be less than 25mm.

l) HV & LV coils single coil multi layer winding shall be used for all capacities of transformers.

m) Tap lead shall be insulated with 1.5 mm thick paper insulation. Inspection of windings prior to tankings shall be done. Manufacturing drawing for the transformer showing various clearance shall have to be approved by the BESCOM.

14.0 TOTAL MINIMUM OIL VOLUME:

Sl. No.	Rating	Oil in Ltrs. (inclusive for oil absorbed in core coil assembly)
1	25KVA	96
2	63KVA	170
3	100KVA	265

NOTE: If the specified amount oil is insufficient, additional quantity may be furnished in the offer and absorption of oil in the core and winding assembly is more than permissible value first filling oil volume should be increased accordingly detailed calculation of absorption shall be submitted.

15.0 BREATHERS :

Breather joints shall be of bolted type. It shall have die cast Aluminium body and inside container for Silica gel shall be of tin. Makes of Breathers shall be subject to BESCOM approval.

The volume of the breather shall be

a) 250 grams of silica gel breather shall be provided for 25 KVA, 63 KVA and 100 KVA transformers.
The breather shall have an inspection window to view the condition of the silica gel.

16.0 TERMINALS:

Brass rods 12mm dia for HT and LT for 25KVA, 63KVA and 100KVA Transformers may be provided.

a) HT/LT Bimetallic connectors shall be provided to 25KVA, 63KVA and 100KVA transformers.

b) The metallic connector shall be L type for LT bushing of distribution transformer of capacity of 100.

c) The HV and LV windings conductor shall not be terminated to the bushing rod directly.

d) The HV winding shall be linked through a terminal lug and copper jumper lead of size 1.6mm dia for 25/63/100KVA transformers. The leads shall be enclosed in kraft paper tube.

e) The LV winding shall be terminated using inverted 'S' type link of size 25x3mm Aluminium strip for 25/63/100KVA transformers.

1) All the leads / links shall be immersed in oil.

2) All the leads/links shall be taken neatly strapped on an insulated press Board/wooden Bus Bar.

17.0 BUSHINGS:

I. For 11KV, 12KV Bushings (confirming to IS: 2099/1986) with single gap arcing horns shall be used and for 433 volts, 1.1KV terminal Bushings confirming to IS: 7421/1974shall be used. Alternatively, the low voltage side may be suitable for adoption of PVC/XLPE cables of suitable size. Bushings of the same voltage class shall be interchangeable. The dimensions of Bushings shall be as per IS-3347 and these Bushings shall be mounted on side of the tank or on the top cover. The bushings mounted on the side shall not have an inclination of more than 30 degrees from the vertical as per CBIP manual and IS-2099. Only sheet metal pocket shall be provided for mounting HV bushings alternately the same can be mounted on pipes. Creepage distance shall not be less than 25mm/KV as per IS: 2099-1986.

II. **Brazing of all internal connections** – All jumpers from windings to bushing shall have a cross section larger than tail winding conductor. For copper, silver brazing alloy to be used. For aluminium, L&T aluminium brazing rods shall be used.

III. The minimum phase to phase and phase to earth external clearances for HV & LV Bushings shall be as follows:

	Minimum clearances	
	Phase to phase (in mm).	**Phase to earth**
HV Bushings	255	140
LV Bushings	75	40

The above 140 mm. clearance does not apply to arcing horn gap.

18.0 TESTS:

Type tests, routine tests and acceptance tests shall be conducted on transformers, of each capacity. All the equipments offered, shall be fully type tested as per the relevant standards at CPRI/ERDA/NABL Accredited Govt. Labs and the date of type test will not be later than 5 years.

19.0 Routine Tests:

1) Measurement of winding resistance. – IS 2026(Part1)
2) Measurement of voltage ratio, polarity, phase sequence and Check of voltage vector relationship IS 2026(Part1)
3) Measurement of impedance voltage/short circuit impedance and load losses at rated current and normal frequency. IS 2026(Part1)
4) Measurement of no load loss current and neutral current. IS 2026(Part1)
5) Measurement insulation resistance. IS 2026(Part1)
6) Induced over voltage withstand test. IS 2026(Part3)
7) Separate source voltage withstand test. IS 2026(Part3)
8) Neutral current measurement: The value of zero sequence current in the neutral of the star winding shall not be more than 2% of the full load current. IS 2026(Part1)
9) Oil samples (one sample per lot) to comply with IS: 1866. IS 2026(Part1)
10) Measurement of no load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.
11) Pressure and vacuum test for checking the deflection. IS 1180(Part1):2014
12) Oil Leakage Test – IS1180(Part1): 2014.

One out of the every consignment of the transformers received at stores, above Routine Tests shall be conducted mandatorily (at Stores). In case of failure, all the transformers in that consignment shall be tested and transformers which pass the test shall be accepted.

20.0 TOLERANCES:

Unless otherwise specified herein, the values of different parameters of the transformers supplied shall be within the tolerance permitted in the IS-1180 on the guaranteed values. Positive tolerance is not applicable for losses and negative tolerance not applicable for cross sections of winding specified.

21.0 FINISHING:

The exterior of the transformer tank and other ferrous fittings shall be thoroughly cleaned, scrapped/sand blasted and given a priming coat and two finishing coats of durable oil the weather resistance paints or enamel. The colour of finishing coats for transformers shall be as follows, as per IS: 5.

a) For 25 KVA - Sky Blue shade No. 101
b) For 63 KVA - Silver Grey shade No. 628
c) For 100 KVA - Brilliant green shade No. 221

BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

Technical Specification for 4 star Rated (New Star 1)11/0.433kV, 3Phase, 50Cycle, Aluminium Wound CRGO core Distribution Transformer of rating 250kVA and 500kVA

1.0 SYSTEM DETAILS:

The transformers shall be suitable for outdoor installation with 3Phase, 50 Hz, 11kV System in which the neutral is effectively earthed and the same shall be suitable for service under fluctuations in supply voltage up to 12.5% permissible under Indian Electricity Rules and the frequency variation of -5% and +2% (47.5Hz to 51.0Hz).

2.0 TECHNICAL PARAMETERS:

a) **Percentage Impedance**:

The Percentage Impedance shall be 4.5% for transformers of 250KVA and 500KVA as per IS 1180(Part 1):2014 with tolerance as per IS: 2026.

b) **INSULATION LEVELS:**

Sl No.	Voltage (kV)	Impulse Voltage (kV Peak)	Power Frequency Voltage (kV)
1	0.433	-	3
2.	11	75	28

3.0 DESIGN & CONSTRUCTION:

Core:

The core shall be of high grade CRGO steel sheet *of* M3 grade or superior to that having low loss and non ageing grain oriented, coated with hot oil proof insulation, bolted together to the frames firmly to prevent vibration or noise. All core clamping bolts shall be effectively insulated.

The complete design of core must ensure permanency of the core losses with continuous working of the transformers. The value of the flux density

shall not be more than 1.7 tesla at 50 HZ.

The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with +12.5% combined voltage and frequency variation from rated voltage and frequency shall not exceed 1.9 Tesla

The construction of core, internal clearances minimum effective area of cross section, minimum Nos. of core steps etc., shall be strictly as per the drawings enclosed.

The transformers core shall not be saturated for any value of V/F ratio to the extent of 112.5% of the rated value of V/F ratio i.e., 11kV/50Hz. (Due to combined effect of voltage and frequency) upto 12.5% without injurious heating at full load conditions the core shall not be saturated.

The Bidder shall furnish necessary design data in support of this condition

The maximum thickness of core laminations shall not exceed 0.23mm. Further the lamination sheets used for top yoke, bottom yoke etc., shall be of single piece.

No load current, shall be measured by energizing the transformers at 433 volts 50 C/S on the secondary for distribution transformers. Increase of voltage by 10% shall not increase the no load current disproportionately high. Test for magnetic balance by connecting the LV phase by phase to rated phase voltage and measurement of an, bn, cn, voltage shall be carried out. The no load current shall not exceed 2% in respect of 250KVA and 500KVA at rated voltage and frequency. Increase of 12.5 % of rated voltage shall not increase the no load current by 5% of full load current.

The minimum

a. Effective core area
b. Number of core steps
c. Internal clearance

Shall be as per the specification and drawings as indicated in the drawings for each capacity.

Minimum effective cross sectional area of the core to be provided are as follows:

1) 250KVA - 146.20 sq.cm.
2) 500KVA - 218.00 sq.cm.

The unbalance current in the neutral shall not be more than 2% of the rated current.

4.0 CORE CLAMPING:

1) M.S. Channel 125 x 65mm for 500KVA & 100x50mm for 250 KVA on top and bottom shall be used for clamping the core.

2) 2 Nos. of 12mm high tensile vertical bolts in parallel in each side shall be provided. The size of the Bolts to be provided in parallel are as follows:
   a) 250 KVA - 2 Nos. of 16mm High Tensile Bolts

   c) 500 KVA - 2 Nos. of 20mm High Tensile Bolts

3) Channel on LV side to be reinforced at equidistance if hole cutting is done for LT lead so as to avoid bending of channel.

4) M.S. Channels are to be painted by varnish and corrosion oil resistant paint before use.

5) Flat or cut channel shall not be used.

6) Core mounting is to be done with ISF 50 X 16 for 250KVA & 500KVA transformer.

7) Clamping arrangement should be strong enough to withstand mechanical forces. The mechanical strength shall be proven by short circuit test.

5.0 TIE BOLTS:

Four horizontal tie rods (or high tensile steel) of 16mm for 250KVA and 20mm for 500KVA to be used. Rods to be effectively insulated with kraft paper tube of thickness I.5mm.

i) All top and bottom Yoke nuts bolts and tie rods shall be painted with oil and corrosion resistant paint before use.
ii) Channel - (top yoke) on LV side to be reinforced at equidistance if hole cutting is done to avoid bending of channel.
iii) The flat provided at the core shall be as per the drawings enclosed and shall not be cut through the length.
iv) Tie rods shall be effectively earthed.
v) Drawing of the building of the core shall be got approved before start of the work

6.0 WINDINGS:

The winding of the transformers shall be connected in delta on the primary side and in star on the secondary side, so as to produce, a positive phase displacement of 30 degrees from the primary to the secondary vectors of the same phase. The neutral of the LT windings shall be brought out to a separate terminal. The vector group shall be Dyn.l1.

a) **Material-** Double layer paper covered Aluminium conductor shall be used.
b) The nominal HV winding cross section shall be as follows:

SL. No.	Rating	
1	250KVA	7.069 Sq.mm.
2	500KVA	12.050 Sq.mm.

c) The nominal LV winding cross section shall be as follows:

SL. No.	Rating	
1	250KVA	286.44 Sq.mm.
2	500KVA	417.06 Sq.mm.

d) LV winding shall be in even layers
e) The neutral formation shall be at top

7.0 LOSSES & IMPEDANCE:

The losses and impedance for various ratings of transformers of 11KV class shall be within the permissible limits. These losses are the maximum permissible.

Rating (KVA)	**Max Losses at 50% loading (watts)**	**Max Losses at 100% loading (watts)**	**Impedance % (subject to tolerance as per IS:2026)**
250	980	2930	4.5
500	1510	4300	4.5

8.0 TOLERANCE:

No positive tolerance shall be allowed on the maximum losses displayed on the label for both 50% and 100% loading values.

9.0 INSULATION, INSULATION MATERIAL & CLEARANCES:

a) Press board blocks at top and bottom of each coil assembly shall be provided. There must be atleast 4 blocks per phase/coil of each of thickness of 30mm. Core wrapper shall be of minimum of 1mm thick.

   The channel at phase barrier board shall be of 2mm thick press board. The tie rod insulation kraft paper shall be of thickness 1mm. Between HV and LV windings addition press Board cylinder of at least 2mm in addition to spacers shall also be provided.

b) No. of vertical/axial wedges for 250 KVA & 500KVA - 12 Nos. shall be provided depending upon the capacity of transformers between LV and HV windings and equispaced around LV. The wedge shall be minimum 6.5mm thick and 8-12mm wide.

c) The inter layer insulation shall be provided between HV windings layers depending on the design. The details shall be furnished.

d) The Neutral connection of LT winding shall be formed using aluminium

strip of same size as that of 'S' type link of size 40x5mm for 250KVA and 70x5 mm for 500KVA transformers.

e) The Delta formation of HV winding shall be made using copper jumper leads of size 2.65MM for 250KVA and 3.75 MM for 500KVA transformers. The leads shall be enclosed in Kraft insulated paper tube.

f) Double paper covering shall be used for winding insulation both for HV & LV windings. Either performed corrugated cylindrical boards or cylindrical compressed boards with spacers shall be provided between HV & LV windings. Press board of type - D IS: 1576 to be used for top and bottom yoke insulation. The electrical grade insulating paper shall be of triveni/Ballarpur or equivalent make subject to approval of BESCOM. Press boards used shall be of M/s. Senapathi whitely or M/s. Raman Boards or equivalent make subject to approval of BESCOM.

g) Radial clearance of LV coil to core (bare conductor) shall not be less than.

1. for 250KVA - 5.0MM
2. for 500KVA - 5.0MM

h) Radial clearance between HV and LV coils shall not be less than 10mm for all capacities.

i) Phase to phase clearance between HV coils shall not be less than 15mm. A minimum of 2 Nos. of 1mm press board shall be used to cover the tie rods.

j) The minimum electrical clearance between the winding and body of the tank (between inside surface of the tank and outside edge of the winding) shall not be less than 30mm.

k) End insulation to earth shall not be less than 25mm.

l) HV & LV coils single coil multi layer winding shall be used for all capacities of transformers.

m) Tap lead shall be insulated with 1.5 mm thick paper insulation. Inspection of windings prior to tankings shall be done. Manufacturing drawing for the transformer showing various clearances shall have to be approved by the BESCOM.

10.0 TOTAL MINIMUM OIL VOLUME:

Sl. No.	Rating	Oil in Ltrs. (inclusive for oil absorbed in core coil assembly)
1	250KVA	410
2	500KVA	610

NOTE: If the absorption of oil in the core and winding assembly is more than permissible value first filling oil volume should be increased accordingly detailed calculation of absorption shall be submitted.

11.0 TERMINALS:

a) Brass rods 12mm dia for HT, 20mm dia for LT for 250 KVA and 12mm dia for HT and 30mm dia for 500KVA transformers shall be provided.

b) Connecting lugs shall be provided confirming to IS: 3347 for LT terminals of 250 and 500KVA Transformers.

c) The metallic connector shall be L type for LT bushing of distribution transformer .

d) The L type clamp shall be suitable to take off two/four circuits of 240 Sq. mm aluminum wire (for 250, 500KVA transformers)

e) The HV and LV windings conductor shall not be terminated to the bushing rod directly.

f) The HV winding shall be linked through a terminal lug and copper jumper lead of size 2.65mm for 250KVA and 3.75mm for 500KVA transformers. The leads shall be enclosed in kraft paper tube.

g) The LV winding shall be terminated using inverted 'S' type link of size 40x5mm for 250KVA and 70x5mm for 500KVA transformers.

   1) All the leads / links shall be immersed in oil.

   2) All the leads/links shall be taken neatly strapped on an insulated press Board/wooden Bus Bar.

12.0 BUSHINGS:

I. For 11KV, 12KV Bushings (confirming to IS: 2099/1986) with single gap arcing horns shall be used and for 433 volts, 1.1KV terminal Bushings confirming to IS: 7421/1974shall be used. Alternatively, the low voltage side may be suitable for adoption of PVC/XLPE cables of suitable size. Bushings of the same voltage class shall be inter changeable. The dimensions of Bushings shall be as per IS-3347 and these Bushings shall be mounted on side of the tank or on the top cover. The bushings mounted on the side shall not have an inclination of more than 30 degrees from the vertical as per CBIP manual and IS-2099. Only sheet metal pocket shall be provided for mounting HV bushings alternately the same can be mounted on pipes. Creepage distance shall not be less than 25mm/KV as per IS: 2099-1986.

II. **Brazing of all internal connections** – All jumpers from windings to bushing shall have a cross section larger than tile winding conductor. For copper, silver brazing alloy to be used. For aluminium, L&T aluminum brazing rods shall be used.

III. The minimum phase to phase and phase to earth external clearances for HV & LV Bushings shall be as follows:

	Minimum clearances	
	Phase to phase (in mm).	Phase to earth
HV Bushings	255	140
LV Bushings	75	40

The above 140 mm. clearance does not apply to arcing horn gap.

13.0 TESTS:

Type tests, routine tests and acceptance tests shall be conducted on transformers, of each capacity. All the equipments offered, shall be fully type tested as per the relevant standards at CPRI/ERDA/NABL Accredited Govt. Labs and the date of type test will not be later than 5 years.

14.0 Routine Tests:

All transformers manufactured shall be subjected to the following routine test, at the manufacturer's works - In accordance with IS:1180(Part I):2014 and IS:2026.

1) Measurement of winding resistance. – IS 2026(Part1)
2) Measurement of voltage ratio, polarity, phase sequence and Check of voltage vector relationship IS 2026(Part1)
3) Measurement of impedance voltage/short circuit impedance and load losses at rated current and normal frequency. IS 2026(Part1)
4) Measurement of no load loss current and neutral current. IS 2026(Part1)
5) Measurement insulation resistance. IS 2026(Part1)
6) Induced over voltage withstand test. IS 2026(Part3)
7) Separate source voltage withstand test. IS 2026(Part3)
8) Neutral current measurement: The value of zero sequence current in the neutral of the star winding shall not be more than 2% of the full load current. IS 2026(Part1)
9) Oil samples (one sample per lot) to comply with IS: 1866. IS 2026(Part1)
10) Measurement of no load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.
11) Pressure and vacuum test for checking the deflection. IS 1180(Part1):2014
12) Oil Leakage Test – IS1180(Part1): 2014.

NOTE: One out of the every consignment of the transformers received at stores, above Routine Tests shall be conducted mandatorily (at Stores). In case of failure, all the transformers in that consignment shall be tested and transformers which pass the test shall be accepted.

15.0 TOLERANCES:

Unless otherwise specified herein, the values of different parameters of the transformers supplied shall be within the tolerance permitted in the IS-2026 on the guaranteed values. Positive tolerance is not applicable for losses

and negative tolerance not applicable for cross sections of winding specified.

16.0 FINISHING:

The exterior of the transformer tank and other ferrous fittings shall be thoroughly cleaned, scrapped/sand blasted and given a priming coat and two finishing coats of durable oil the weather resistance paints or enamel. The colour of finishing coats for transformers shall be as follows, as per IS: 5.

a) For 250 KVA -
b) For 500 KVA - } Dark admiral grey shade No. 632

BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

Technical Specification for 5Star Rated (New Star2)11/0.433kV, 3Phase, 50Cycle, Aluminium Wound CRGO Core Distribution Transformer of rating 25/63kVA

1.0 SYSTEM DETAILS:

The transformers shall be suitable for outdoor installation with 3Phase, 50 Hz, 11kV System in which the neutral is effectively earthed and the same shall be suitable for service under fluctuations in supply voltage up to 12.5% permissible under Indian Electricity Rules and the frequency variation of -5% and +2% (47.5Hz to 51.0Hz).

2.0 TECHNICAL REQUIREMENTS:

Core Material: CRGO Material

The core shall be high grade stack/wound type of high grade cold rolled grain oriented annealed steel lamination having low loss and good grain proper ties, coated with hot oil proof insulation, bolted together and to the framed to prevent vibration or noise. The core shall be stress relived by annealing under inert atmosphere if required. The complete design of core must ensure permanency of the core loss with continuous working of the transformers. The value of the maximum flux density allowed in the design and grade of lamination used shall be clearly stated in the offer.

The bidder should offer the core for inspection and approval by the purchaser during manufacturing stage.

The transformers core shall be suitable for over fluxing (due to combined effect of voltage and frequency) up to 12.5% without injurious heating at full load conditions and shall not get saturated. The bidder shall furnish necessary design data in support of this situation.

No-load current shall not exceed 3% of full load current and will be measured by energising the transformer at 433 volts, 50Hz on the secondary. Increase of voltage of 433 volts by 12.5% shall not increase the no-load current by 6% (maximum) full load current.

3.0 WINDINGS:

The primary winding shall be connected in delta and the secondary winding in star (vector symbol Dyn11) so as to produce, a positive phase displacement of 30 degrees from the primary to the secondary vectors of the same phase. The neutral of the secondary winding shall be brought out to a separate insulated terminal.

HV and LV windings shall be wound from Super Enamel covered/ Double Paper covered aluminium conductor.

LV windings shall be such that neutral formation will be at top.

Inter layer insulation shall be Nomex/Epoxy dotted Kraft Paper.

Proper bonding of inter layer insulation with the conductor shall be ensured. Test for bonding strength shall be conducted.

Dimensions of winding coils are very critical. Dimensional tolerances for windings coils shall be with in limits as specified in Guaranteed Technical Particulars.

Current density for HV and LV winding should not be more than 1.6 Ampere per sq mm for aluminium conductor.

The core/coil assembly shall be securely held in position to avoid any movement under short circuit conditions.

Joints in the winding shall be avoided. However, if jointing is necessary the joints shall be properly brazed and the resistance of the joints shall be less than that of parent conductor.

4.0 PERCENTAGE IMPENDENCE:

The value of impedance of transformer at 75°C shall be 4.5% and tolerance shall be in accordance with IS: 1180(part I) 2014.

5.0 INSULATION LEVELS:

Sl No.	Voltage (kV)	Impulse Voltage (kV Peak)	Power Frequency Voltage (kV)
1	0.433	-	3
2.	11	75	28

6.0 DESIGN & CONSTRUCTION:

CORE:

a) The core shall be of high grade CRGO steel sheet of 23HP90 or superior Grade to that having low loss and non ageing grain oriented, coated with hot oil proof

insulation, bolted together to the frames firmly to prevent vibration or noise. All core clamping bolts shall be effectively insulated.

b) The complete design of core must ensure permanency of the core losses with continuous working of the transformers. The value of the flux density shall not be more than 1.7 tesla at 50 HZ and maximum specific core loss shall not be more than 0.9 watts per kg.

c) The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with +12.5% combined voltage and frequency variation from rated voltage and frequency shall not exceed 1.9 Tesla

d) The construction of core, internal clearances minimum effective area of cross section, minimum Nos. of core steps etc., shall be strictly as per the drawings.

e) The transformers core shall not be saturated for any value of V/F ratio to the extent of 112.5% of the rated value of V/F ratio i.e., 11kV/50Hz. (Due to combined effect of voltage and frequency) upto 12.5% without injurious heating at full load conditions the core shall not be saturated.

f) The Bidder shall furnish necessary design data in support of this condition

g) The maximum thickness of core laminations shall not exceed 0.23mm. Further the lamination sheets used for top yoke, bottom yoke etc., shall be of single piece.

h) No load current, shall be measured by energizing the transformers at 433 volts 50 C/S on the secondary for distribution transformers. Increase of voltage by 10% shall not increase the no load current disproportionately high. Test for magnetic balance by connecting the LV phase by phase to rated phase voltage and measurement of an, bn, cn, voltage shall be carried out. The no load current, shall not exceed 3% in respect of 100KVA and below distribution transformers, at rated voltage and frequency

i) The minimum

   a. Effective core area
   b. Number of core steps
   c. Internal clearance

   Shall be furnished by the bidder along with the bid offer.

   Minimum effective cross sectional area of the core to be provided are as follows:

   1) 25KVA - 49.20 sq.cm.

   2) 63KVA - 91.30 sq.cm.

j) The unbalance current in the neutral shall not be more than 2% of the rated current.

7.0 CORE CLAMPING:

1) M.S.Channel 75 x 40mm on top and bottom shall be used for clamping the core.
2) 2 Nos. of 12mm high tensile vertical bolts in parallel in each side shall be provided. The size of the Bolts to be provided in parallel are as follows:
   a) 25, 63KVA - 2 Nos. of 12mm High Tensile Bolts
3) Channel on LV side to be reinforced at equidistance if hole cutting is done for LT lead so as to avoid bending of channel.
4) M.S. Channels are to be painted by varnish and corrosion oil resistant paint before use.

5) Flat or cut channel shall not be used.
6) Core mounting is to be done with ISF 50x10.
7) Clamping arrangement should be strong enough to withstand mechanical forces. The mechanical strength shall be proven by short circuit test.

8.0 TIE BOLTS:

Four horizontal tie rods (or high tensile steel) of 12mm dia to be used. Rods to be effectively insulated with kraft paper tube of thickness I.5mm.

i) All top and bottom Yoke nuts bolts and tie rods shall be painted with oil and corrosion resistant paint before use.
ii) Channel - (top yoke) on LV side to be reinforced at equidistance if hole cutting is done to avoid bending of channel.
iii) The flat provided at the core shall be as per the drawings enclosed and shall not be cut through the length.
iv) Tie rods shall be effectively earthed.
v) Drawing of the building of the core shall be got approved before start of the work

9.0 WINDINGS:

a) **Material-** Double layer paper covered Aluminium conductor shall be used.
b) The nominal HV winding cross section shall be as follows:

SL. No.	Rating	
1	25KVA	0.9503 Sq.mm.
2	63KVA	2.835 Sq.mm.

c) The nominal LV winding cross section shall be as follows:

SL. No.	Rating	
1	25KVA	40.3 Sq.mm.
2	63KVA	90.44 Sq.mm.

d) LV winding shall be in even layers
e) The neutral formation shall be at top

Note: If any other than the above cross section of HV/LV windings, details shall be furnished.

10.0 LOSSES AND IMPEDANCE:

The bidder shall guarantee individually the no-load losses and loss without any positive tolerance. The bidder shall also guarantee the total losses at 50% and 100% load condition (at rated voltage and frequency and at 75°C).

The maximum allowable losses & impedance at rated voltage and rated frequency permitted at 75°C for 11/0.433kV transformers as follows:

Voltage ratio:	Ratings (kVA)	Max Losses at 50% loading (watts)	Max Losses at 100% loading (watts)	Impedance % (subject to tolerance as per IS:2026)
11kV/433-250V	25	175	595	4.5
	63	300	1050	

11.0 TOLERANCE:

No positive tolerance shall be allowed on the maximum losses displayed on the label for both 50% and 100% loading values.

12.0 INSULATION, INSULATION MATERIAL& CLERANCES:

Electrical grade insulation epoxy dotted Kraft Paper/Nomex and pressboard of standard make or any make other superior material subject to approval of the BESCOM shall be used.

All spacers, axial wedges/runners used in windings shall be made of pre-compressed Pressboard-solid, conforming to type B 3.1 of IEC641-3-2. In case of cross- over coil winding of HV all spacers shall be properly sheared and dovetail punched to ensure proper locking. All axial wedges/runners shall be properly milled to dovetail shape so that they pass through the designed spacers freely. Insulation shearing, cutting, milling and punching operations shall be carried out in such a way, that there should not be any burr and dimensional variations.

a) Press board blocks at top and bottom of each coil assembly shall be provided. There must be atleast 4 blocks per phase/coil of each of thickness of 30mm. Core wrapper shall be of minimum of 1mm thick.

   The channel at phase barrier board shall be of 2mm thick press board. The tie rod insulation craft paper shall be of thickness 1mm. Between HV and LV windings addition press Board cylinder of at least 2mm in addition to spacers shall also be provided.

b) No. of vertical/axial wedges, minimum 18 Nos., shall be provided depending upon the capacity of transformers between LV and HV windings and equispaced around LV. The wedge shall be minimum 6.5mm thick wide.
c) The inter layer insulation shall be provided between HV windings layers depending on the design. The details shall be furnished.
d) The Neutral connection of LT winding shall be formed using aluminium strip of same size as that of 'S' type link of size 25x3mm. Aluminium strip for 25/63 KVA transformers.
e) The Delta formation of HV winding shall be made using copper jumper leads of size 1.6mm dia. for 25/63 KVA, 2.65MM transformers. The leads shall be enclosed in Kraft insulated paper tube.
f) Double paper covering shall be used for winding insulation both for HV & LV windings. Either performed corrugated cylindrical boards or cylindrical compressed boards with spacers shall be provided between HV & LV windings. Press board of type - D IS: 1576 to be used for top and bottom yoke insulation. The electrical grade insulating paper shall be of Triveni/Ballarpur or equivalent make subject to approval of BESCOM. Press boards used shall be of M/s. Senapathi whitely or M/s. Raman Boards or equivalent make subject to approval of BESCOM.
g) Radial clearance of LV coil to core (bare conductor) shall not be less than.
   1. for 25 KVA - 3.5MM
   2. for 63 KVA - 3.5MM
h) Radial clearance between HV and LV coils shall not be less than 10mm for all capacities.
i) Phase to phase clearance between HV coils shall not be less than 15mm. A minimum of 2 Nos. of 1mm press board shall be used to cover the tie rods.
j) The minimum electrical clearance between the winding and body of the tank

(between inside surface of the tank and outside edge of the winding) shall not be less than 30mm.

k) End insulation to earth shall not be less than 25mm.

l) HV & LV coils single coil multi layer winding shall be used for all capacities of transformers.

m) Tap lead shall be insulated with 1.5 mm thick paper insulation. Inspection of windings prior to tanking shall be done. Manufacturing drawing for the transformer showing various clearance shall have to be approved by the BESCOM.

13.0 TOTAL MINIMUM OIL VOLUME:

Sl. No.	Rating	Oil in Ltrs. (inclusive for oil absorbed in core coil assembly)
1	25KVA	115
2	63KVA	190

NOTE: If the specified amount oil is insufficient, additional quantity may be furnished in the offer and absorption of oil in the core and winding assembly is more than permissible value first filling oil volume should be increased accordingly detailed calculation of absorption shall be submitted.

14.0 BREATHERS :

Breather joints shall be of bolted type. It shall have die cast Aluminium body and inside container for Silica gel shall be of tin. Makes of Breathers shall be subject to BESCOM approval.

The volume of the breather shall be

a) 250 grams of silica gel breather shall be provided for 25 KVA & 63 KVA transformers.

b) The breather shall have an inspection window to view the condition of the silica gel.

15.0 TERMINALS:

Brass rods 12mm dia for HT and LT for 25KVA & 63KVA Transformers may be provided.

a) HT/LT Bimetallic connectors shall be provided to 25KVA and 63KVA transformers.

b) The metallic connector shall be L type for LT bushing of distribution transformer of capacity of 100.

c) The HV and LV windings conductor shall not be terminated to the bushing rod directly.

d) The HV winding shall be linked through a terminal lug and copper jumper lead of size 1.6mm dia for 25/63KVA transformers. The leads shall be enclosed in kraft paper tube.

e) The LV winding shall be terminated using inverted 'S' type link of size 25x3mm Aluminium strip for 25/63KVA transformers.

1) All the leads / links shall be immersed in oil.

2) All the leads/links shall be taken neatly strapped on an insulated press Board/wooden Bus Bar.

16.0 BUSHINGS:

I. For 11KV, 12KV Bushings (confirming to IS: 2099/1986) with single gap arcing

horns shall be used and for 433 volts, 1.1KV terminal Bushings confirming to IS: 7421/1974shall be used. Alternatively, the low voltage side may be suitable for adoption of PVC/XLPE cables of suitable size. Bushings of the same voltage class shall be interchangeable. The dimensions of Bushings shall be as per IS-3347 and these Bushings shall be mounted on side of the tank or on the top cover. The bushings mounted on the side shall not have an inclination of more than 30 degrees from the vertical as per CBIP manual and IS-2099. Only sheet metal pocket shall be provided for mounting HV bushings alternately the same can be mounted on pipes. Creepage distance shall not be less than 25mm/KV as per IS: 2099-1986.

II. **Brazing of all internal connections** – All jumpers from windings to bushing shall have a cross section larger than tail winding conductor. For copper, silver brazing alloy to be used. For aluminium, L&T aluminium brazing rods shall be used.

III. The minimum phase to phase and phase to earth external clearances for HV & LV Bushings shall be as follows:

	Minimum clearances	
	Phase to phase (in mm).	**Phase to earth**
HV Bushings	255	140
LV Bushings	75	40

The above 140 mm. clearance does not apply to arcing horn gap.

17.0 TESTS:

Type tests, routine tests and acceptance tests shall be conducted on transformers, of each capacity. All the equipments offered, shall be fully type tested as per the relevant standards at CPRI/ERDA/NABL Accredited Govt. Labs and the date of type test will not be later than 5 years.

18.0 Routine Tests:

1) Measurement of winding resistance. – IS 2026(Part1)
2) Measurement of voltage ratio, polarity, phase sequence and Check of voltage vector relationship IS 2026(Part1)
3) Measurement of impedance voltage/short circuit impedance and load losses at rated current and normal frequency. IS 2026(Part1)
4) Measurement of no load loss current and neutral current. IS 2026(Part1)
5) Measurement insulation resistance. IS 2026(Part1)
6) Induced over voltage withstand test. IS 2026(Part3)
7) Separate source voltage withstand test. IS 2026(Part3)
8) Neutral current measurement: The value of zero sequence current in the neutral of the star winding shall not be more than 2% of the full load current. IS 2026(Part1)
9) Oil samples (one sample per lot) to comply with IS: 1866. IS 2026(Part1)
10) Measurement of no load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.
11) Pressure and vacuum test for checking the deflection. IS 1180(Part1):2014
12) Oil Leakage Test – IS1180(Part1): 2014.

One out of the every consignment of the transformers received at stores, above Routine Tests shall be conducted mandatorily (at Stores). In case of failure, all the transformers in that consignment shall be tested and transformers which pass the test shall be accepted.

19.0 TOLERANCES:

Unless otherwise specified herein, the values of different parameters of the transformers supplied shall be within the tolerance permitted in the IS-1180 on the guaranteed values. Positive tolerance is not applicable for losses and negative tolerance not applicable for cross sections of winding specified.

20.0 FINISHING:

The exterior of the transformer tank and other ferrous fittings shall be thoroughly cleaned, scrapped/sand blasted and given a priming coat and two finishing coats of durable oil the weather resistance paints or enamel. The colour of finishing coats for transformers shall be as follows, as per IS: 5.

a) For 25 KVA - Sky Blue shade No. 101
b) For 63 KVA - Silver Grey shade No. 628

BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED

Technical Specification for 5 star Rated (New Star 2)11/0.433kV, 3Phase, 50Cycle, Aluminium Wound CRGO core Distribution Transformer of rating 100kVA, 250kVA and 500kVA.

1.0 SYSTEM DETAILS:

The transformers shall be suitable for outdoor installation with 3Phase, 50 Hz, 11kV System in which the neutral is effectively earthed and the same shall be suitable for service under fluctuations in supply voltage up to 12.5% permissible under Indian Electricity Rules and the frequency variation of -5% and +2% (47.5Hz to 51.0Hz).

2.0 TECHNICAL PARAMETERS:

a) **Percentage Impedance**:

The Percentage Impedance shall be 4.5% for transformers of 100kVA, 250KVA and 500KVA as per IS 1180(Part 1):2014 with tolerance as per IS: 2026.

b) **INSULATION LEVELS:**

Sl No.	Voltage (kV)	Impulse Voltage (kV Peak)	Power Frequency Voltage (kV)
1	0.433	-	3
2.	11	75	28

3.0 DESIGN & CONSTRUCTION:

Core:

a. The core shall be of high grade CRGO steel sheet *of* 23HP90 Grade or superior Grade having low loss and non ageing grain oriented, coated with hot oil proof insulation, bolted together to the frames firmly to prevent vibration or noise. All core clamping bolts shall be effectively insulated.
b. The complete design of core must ensure permanency of the core losses with continuous working of the transformers. The value of the flux density shall not be more than 1.7 tesla at 50 HZ and maximum specific core loss shall not be more than 0.9 watts per kg.

c. The maximum flux density in any part of the core and yoke at rated voltage and frequency shall be such that the flux density with +12.5% combined voltage and frequency variation from rated voltage and frequency shall not exceed 1.9 Tesla.

d. The construction of core, internal clearances minimum effective area of cross section, minimum Nos. of core steps etc., shall be strictly as per the drawings.

b) The transformers core shall not be saturated for any value of V/F ratio to the extent of 112.5% of the rated value of V/F ratio i.e., 11kV/50Hz. (Due to combined effect of voltage and frequency) upto 12.5% without injurious heating at full load conditions the core shall not be saturated.

c) The Bidder shall furnish necessary design data in support of this condition

d) The maximum thickness of core laminations shall not be more than 0.23mm. Further the lamination sheets used for top yoke, bottom yoke etc., shall be of single piece.

e) No load current, shall be measured by energizing the transformers at 433 volts 50 C/S on the secondary for distribution transformers. Increase of voltage by 10% shall not increase the no load current disproportionately high. Test for magnetic balance by connecting the LV phase by phase to rated phase voltage and measurement of an, bn, cn, voltage shall be carried out. The no load current shall not exceed 2% in respect of 100kVA, 250KVA and 500KVA at rated voltage and for rated frequency. Increase of 12.5 % of rated voltage shall not increase the no load current by 5% of full load current.

f) The minimum

   a. Effective core area
   b. Number of core steps
   c. Internal clearance

g) Minimum effective cross sectional area of the core to be provided are as follows:

   1) 100kVA - 107.30 sq.cm.
   2) 250KVA - 170.30 sq.cm.
   3) 500KVA - 244.20 sq.cm.

   Note: If the manufacturer uses the better quality CRGO steel for the core the manufacturer has to furnish the area of cross section of the core along with the design details.

h) The unbalance current in the neutral shall not be more than 2% of the rated current.

4.0 CORE CLAMPING:

1) M.S. Channel 125 x 65mm for 500KVA, 100x50mm for 250 KVA & 75x40mm channel on top and bottom shall be used for clamping the core.

2) 2 Nos. of 12mm high tensile vertical bolts in parallel in each side shall be provided. The size of the Bolts to be provided in parallel are as follows:

a) 100kVA - 2 Nos. of 12mm High Tensile Bolts.
b) 250 KVA - 2 Nos. of 16mm High Tensile Bolts.
c) 500 KVA - 2 Nos. of 20mm High Tensile Bolts.

3) Channel on LV side to be reinforced at equidistance if hole cutting is done for LT lead so as to avoid bending of channel.

4) M.S. Channels are to be painted by varnish and corrosion oil resistant paint before use.

5) Flat or cut channel shall not be used.

6) Core mounting is to be done with ISF 50x10 for 100kVA and 50X16 for 250KVA & 500KVA transformer.

7) Clamping arrangement should be strong enough to withstand mechanical forces. The mechanical strength shall be proven by short circuit test.

5.0 TIE BOLTS:

Four horizontal tie rods (or high tensile steel) of Rods of dia 12mm for 100kVA,16mm for 250KVA and 20mm for 500KVA to be used. Rods to be effectively insulated with kraft paper tube of thickness I.5mm.

i) All top and bottom Yoke nuts bolts and tie rods shall be painted with oil and corrosion resistant paint before use.
ii) Channel - (top yoke) on LV side to be reinforced at equidistance if hole cutting is done to avoid bending of channel.
iii) The flat provided at the core shall be as per the drawings enclosed and shall not be cut through the length.
iv) Tie rods shall be effectively earthed.
v) Drawing of the building of the core shall be got approved before start of the work

6.0 WINDINGS:

The winding of the transformers shall be connected in delta on the primary side and in star on the secondary side, so as to produce, a positive phase displacement of 30 degrees from the primary to the secondary vectors of the same phase. The neutral of the LT windings shall be brought out to a separate terminal. The vector group shall be Dyn.l1.

a) **Material-** Double layer paper covered Aluminium conductor shall be used.
b) The nominal HV winding cross section shall be as follows:

SL. No.	Rating	
1	100kVA	4.524 Sq.mm
2	250KVA	17.65 Sq.mm.
3	500KVA	33.89 Sq.mm.

c) The nominal LV winding cross section shall be as follows:

SL. No.	Rating	
1	100kVA	159.32 Sq.mm
2	250KVA	293.56 Sq.mm.
3	500KVA	719.28 Sq.mm.

d) LV winding shall be in even layers
e) The neutral formation shall be at top

Note: If the manufacturer use the appropriate HV/LV winding cross sections less than the above mentioned values so as to comply with the maximum losses at 50% load and at 100% load and the temperature rise limits specified in IS 1180. The design details shall be furnished along with the GTP for approval.

7.0 LOSSES & IMPEDANCE:

The losses and impedance for various ratings of transformers of 11KV class shall be within the permissible limits. These losses are the maximum permissible.

Rating (KVA)	Max Losses at 50% loading (watts)	Max Losses at 100% loading (watts)	Impedance % (subject to tolerance as per IS:2026)
100	435	1500	4.5
250	920	2700	4.5
500	1430	4100	4.5

8.0 TOLERANCE:

No positive tolerance shall be allowed on the maximum losses mentioned above for both 50% and 100% loading values.

9.0 INSULATION, INSULATION MATERIAL & CLEARANCES:

a) Press board blocks at top and bottom of each coil assembly shall be provided. There must be atleast 4 blocks per phase/coil of each of thickness of 30mm. Core wrapper shall be of minimum of 1mm thick.
The channel at phase barrier board shall be of 2mm thick press board. The tie rod insulation kraft paper shall be of thickness 1mm. Between HV and LV windings addition press Board cylinder of at least 2mm in addition to spacers shall also be provided.

b) No. of vertical/axial wedges for 100kVA, 250 KVA & 500KVA minimum 18Nos. shall be provided depending upon the capacity of transformers between LV and HV windings and equispaced around LV. The wedge shall be minimum 6.5mm thick and 8-12mm wide.

c) The inter layer insulation shall be provided between HV windings layers depending on the design. The details shall be furnished.

d) The Neutral connection of LT winding shall be formed using aluminium strip of same size as that of 'S' type link of size 25x3mm for 100kVA, 40x5mm for 250KVA and 70x5 mm for 500KVA transformers.

e) The Delta formation of HV winding shall be made using copper jumper leads of size 1.65MM for 100kVA, 2.65MM for 250KVA and 3.75 MM for 500KVA transformers. The leads shall be enclosed in Kraft insulated paper tube.

f) Double paper covering shall be used for winding insulation both for HV & LV windings. Either performed corrugated cylindrical boards or cylindrical compressed boards with spacers shall be provided between HV & LV windings. Press board of type - D IS: 1576 to be used for top and bottom yoke insulation. The electrical grade insulating paper shall be of triveni/Ballarpur or equivalent make subject to approval of BESCOM. Press boards used shall be of M/s. Senapathi whitely or M/s. Raman Boards or equivalent make subject to approval of BESCOM.

g) Radial clearance of LV coil to core (bare conductor) shall not be less than.
   1. for 100kVA - 4.5MM.
   2. for 250KVA - 5.0MM.
   3. for 500KVA - 5.0MM.

h) Radial clearance between HV and LV coils shall not be less than 10mm for all

capacities.

i) Phase to phase clearance between HV coils shall not be less than 15mm. A minimum of 2 Nos. of 1mm press board shall be used to cover the tie rods.

j) The minimum electrical clearance between the winding and body of the tank (between inside surface of the tank and outside edge of the winding) shall not be less than 30mm.

k) End insulation to earth shall not be less than 25mm.

l) HV & LV coils single coil multi layer winding shall be used for all capacities of transformers.

m) Tap lead shall be insulated with 1.5 mm thick paper insulation. Inspection of windings prior to tankings shall be done. Manufacturing drawing for the transformer showing various clearances shall have to be approved by the BESCOM.

10.0 TOTAL MINIMUM OIL VOLUME:

Sl. No.	Rating	Oil in Ltrs. (inclusive for oil absorbed in core coil assembly)
1	100kVA	225
2	250KVA	490
3	500KVA	700

NOTE: If the absorption of oil in the core and winding assembly is more than permissible value first filling oil volume should be increased accordingly detailed calculation of absorption shall be submitted.

11.0 BREATHERS :

Breather joints shall be of bolted type. It shall have die cast Aluminium body and inside container for Silicagel shall be of tin. Make of Breathers shall be subject to BESCOM approval.

For 100kVA -250Gram, 250 KVA and 500 KVA transformers 500Gramsbreather shall be provided.

The breather shall have an inspection window to view the condition of the silicagel.

12.0 TERMINALS:

a) Brass rods 12mm dia for HT for all the capacities and 14mm dia for LT for 100 KVA, 20mm dia for LT for 250 KVA & 30mm dia for 500KVA transformers shall be provided.

b) Connecting lugs shall be provided confirming to IS: 3347 for LT terminals for all the capacities of Transformers.

c) The metallic connector shall be L type for LT bushing of distribution transformer .

d) The L type clamp shall be suitable to take off two/four circuits of 240 Sq. mm aluminum wire (for 250, 500KVA transformers)

e) The HV and LV windings conductor shall not be terminated to the bushing rod directly.

f) The HV winding shall be linked through a terminal lug and copper jumper lead of size 1.65mm for 100kVA, 2.65mm for 250KVA and 3.75mm for 500KVA transformers. The leads shall be enclosed in kraft paper tube.

g) The LV winding shall be terminated using inverted 'S' type link of size 25x3mm for 100kVA, 40x5mm for 250KVA and 70x5mm for 500KVA transformers.

1) All the leads / links shall be immersed in oil.

2) All the leads/links shall be taken neatly strapped on an insulated press Board/wooden Bus Bar.

13.0 BUSHINGS:

I. For 11KV, 12KV Bushings (confirming to IS: 2099/1986) with single gap arcing horns shall be used and for 433 volts, 1.1KV terminal Bushings confirming to IS: 7421/1974shall be used. Alternatively, the low voltage side may be suitable for adoption of PVC/XLPE cables of suitable size. Bushings of the same voltage class shall be inter changeable. The dimensions of Bushings shall be as per IS-3347 and these Bushings shall be mounted on side of the tank or on the top cover. The bushings mounted on the side shall not have an inclination of more than 30 degrees from the vertical as per CBIP manual and IS-2099. Only sheet metal pocket shall be provided for mounting HV bushings alternately the same can be mounted on pipes. Creepage distance shall not be less than 25mm/KV as per IS: 2099-1986.

II. **Brazing of all internal connections** – All jumpers from windings to bushing shall have a cross section larger than tile winding conductor. For copper, silver brazing alloy to be used. For aluminium, L&T aluminum brazing rods shall be used.

III. The minimum phase to phase and phase to earth external clearances for HV & LV Bushings shall be as follows:

	Minimum clearances (in mm)	
	Phase to phase	Phase to earth
HV Bushings	255	140
LV Bushings	75	40

The above 140 mm. clearance does not apply to arcing horn gap.

14.0 TESTS:

Type tests, routine tests and acceptance tests shall be conducted on transformers, of each capacity. All the equipments offered, shall be fully type tested as per the relevant standards at CPRI/ERDA/NABL Accredited Govt. Labs and the date of type test will not be later than 5 years.

15.0 Routine Tests:

All transformers manufactured shall be subjected to the following routine test, at the manufacturer's works - In accordance with IS:1180(Part I):2014 and IS:2026.

1) Measurement of winding resistance. – IS 2026(Part1)
2) Measurement of voltage ratio, polarity, phase sequence and Check of voltage vector relationship IS 2026(Part1)
3) Measurement of impedance voltage/short circuit impedance and load losses at rated current and normal frequency. IS 2026(Part1)
4) Measurement of no load loss current and neutral current. IS 2026(Part1)
5) Measurement insulation resistance. IS 2026(Part1)
6) Induced over voltage withstand test. IS 2026(Part3)
7) Separate source voltage withstand test. IS 2026(Part3)
8) Neutral current measurement: The value of zero sequence current in the neutral of the star winding shall not be more than 2% of the full load current. IS 2026(Part1)
9) Oil samples (one sample per lot) to comply with IS: 1866. IS 2026(Part1)
10) Measurement of no load losses and magnetizing current at rated frequency and 90%, 100% and 110% rated voltage.
11) Pressure and vacuum test for checking the deflection. IS 1180(Part1):2014
12) Oil Leakage Test – IS1180(Part1): 2014.

NOTE: One out of the every consignment of the transformers received at stores, above Routine Tests shall be conducted mandatorily (at Stores). In case of failure, all the transformers in that consignment shall be tested and transformers which pass the test shall be accepted.

16.0 TOLERANCES:

Unless otherwise specified herein, the values of different parameters of the transformers supplied shall be within the tolerance permitted in the IS-2026 on the guaranteed values. Positive tolerance is not applicable for losses and negative tolerance not applicable for cross sections of winding specified.

17.0 FINISHING:

The exterior of the transformer tank and other ferrous fittings shall be thoroughly cleaned, scrapped/sand blasted and given a priming coat and two finishing coats of durable oil the weather resistance paints or enamel. The colour of finishing coats for transformers shall be as follows, as per IS: 5.

a) For 100 kVA - Brilliant Green shade No.221
b) For 250 KVA - } Dark admiral grey shade No. 632
c) For 500 KVA - }